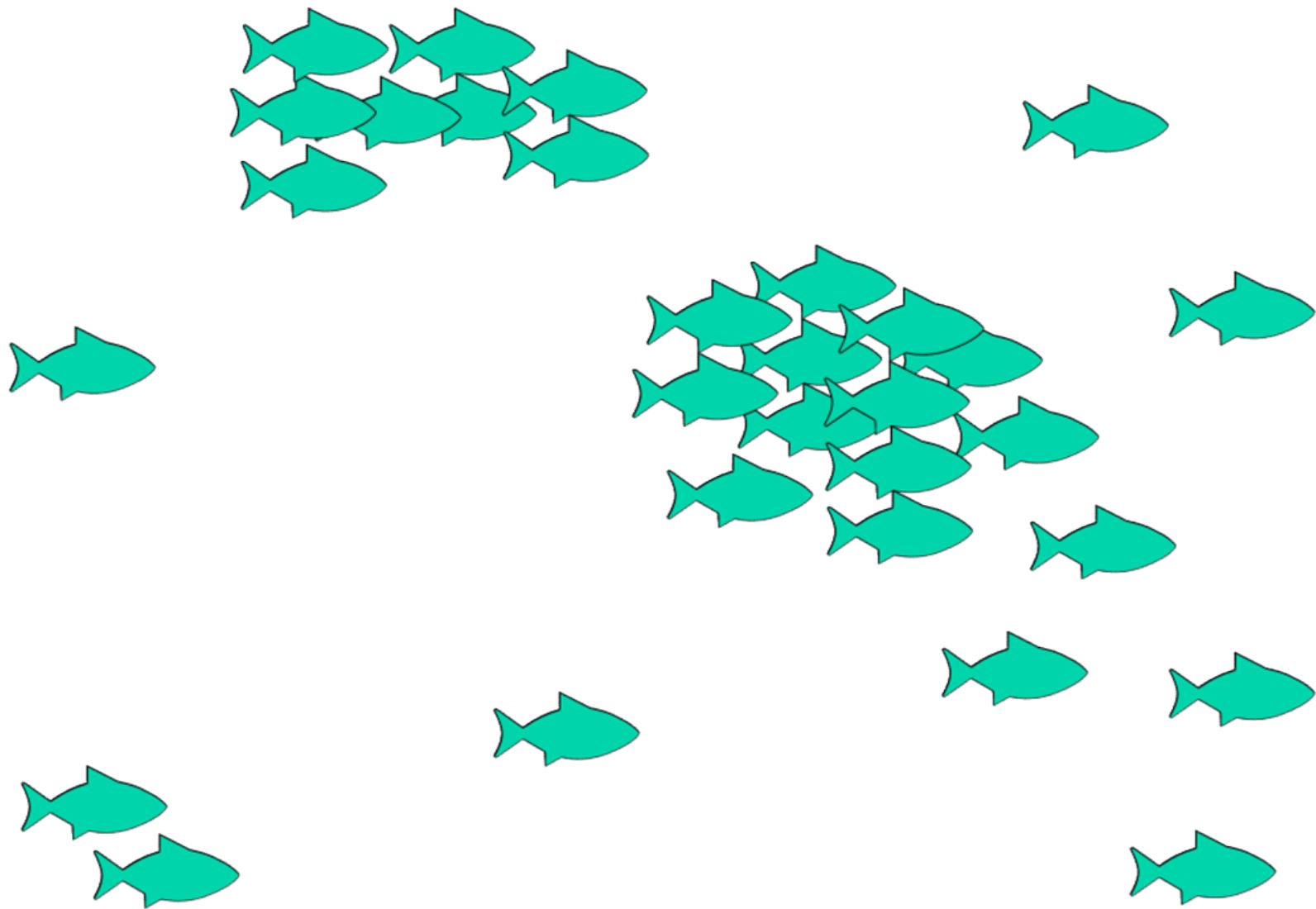
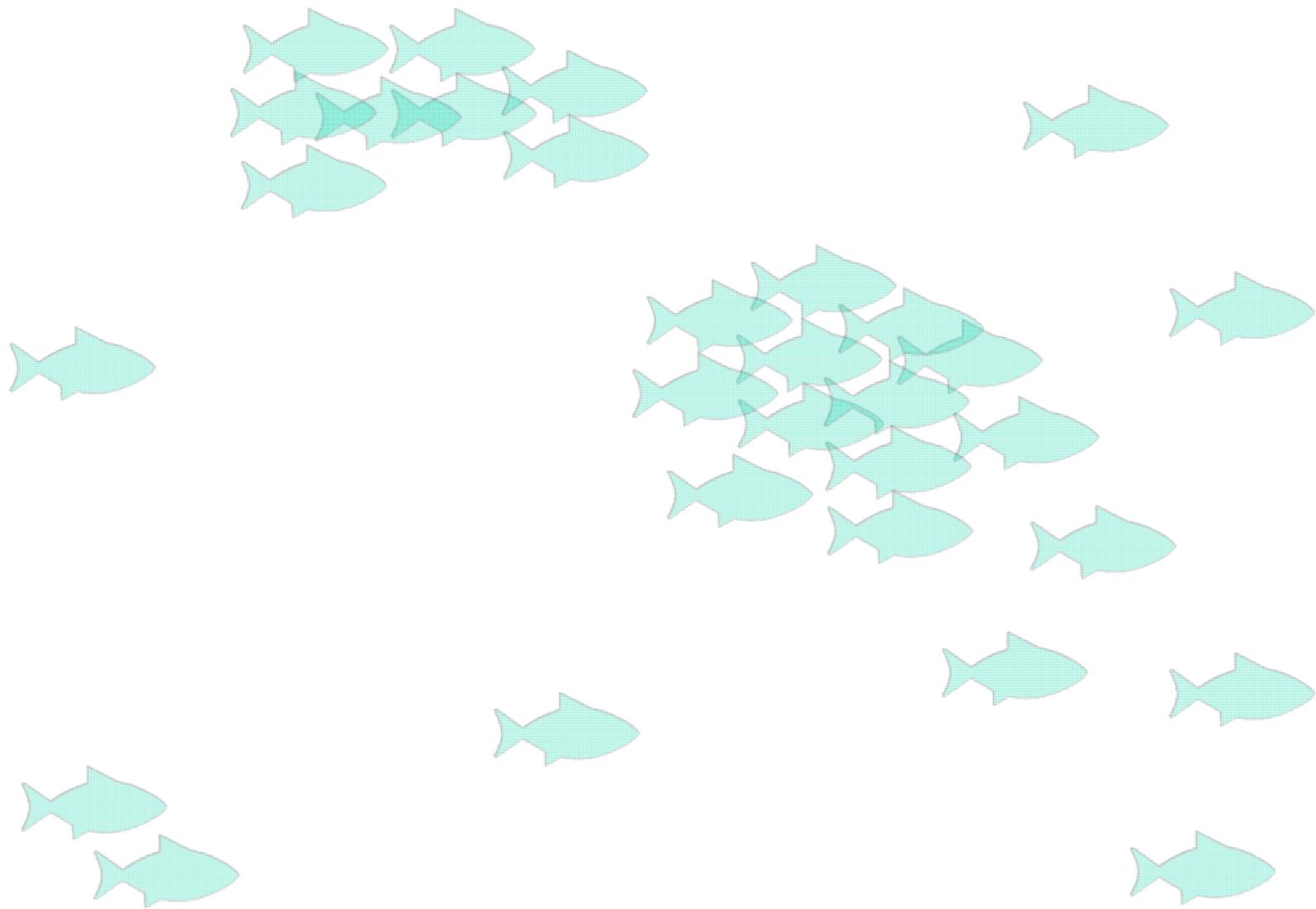


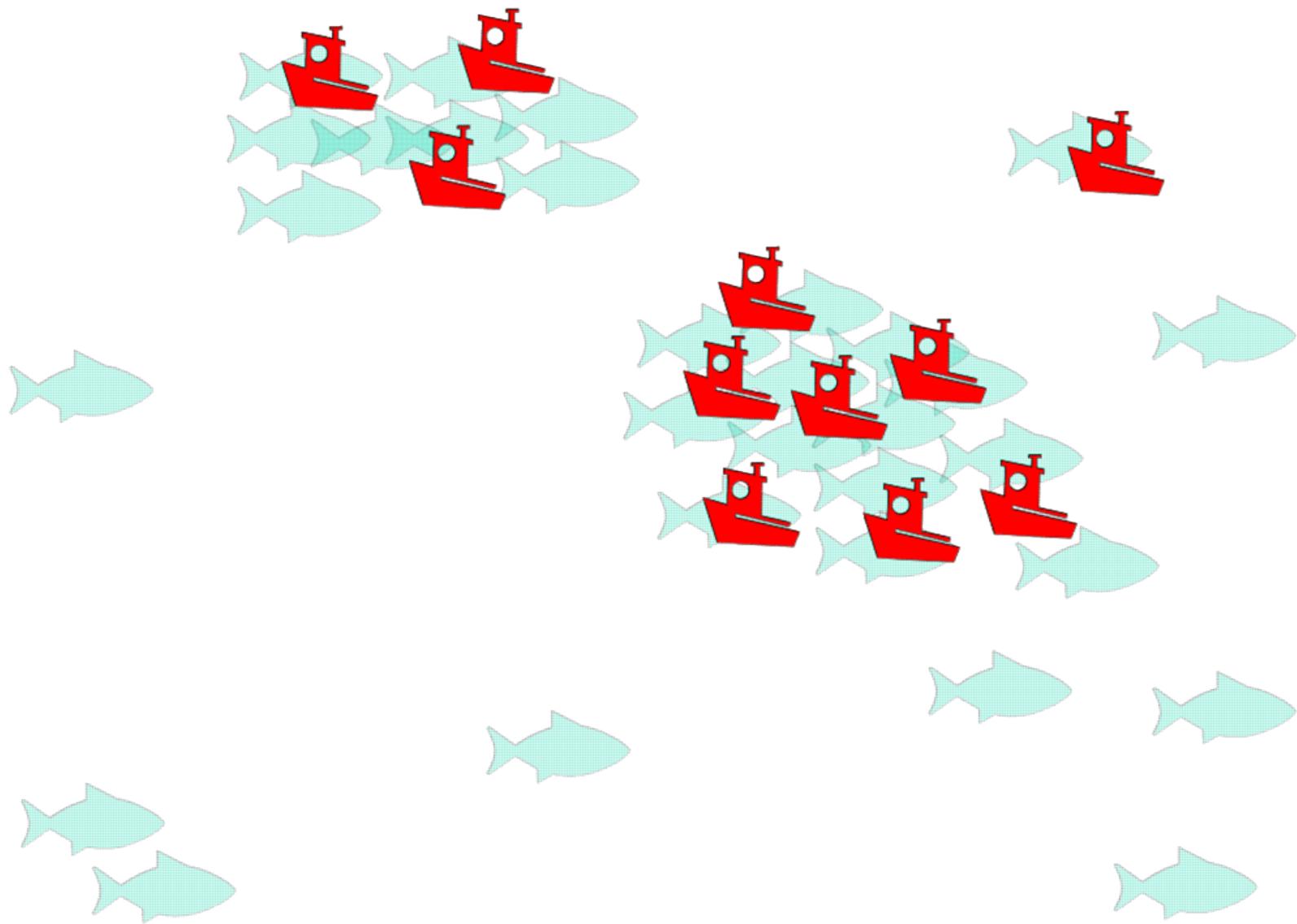
# Fishery-dependent data in a spatio-temporal context

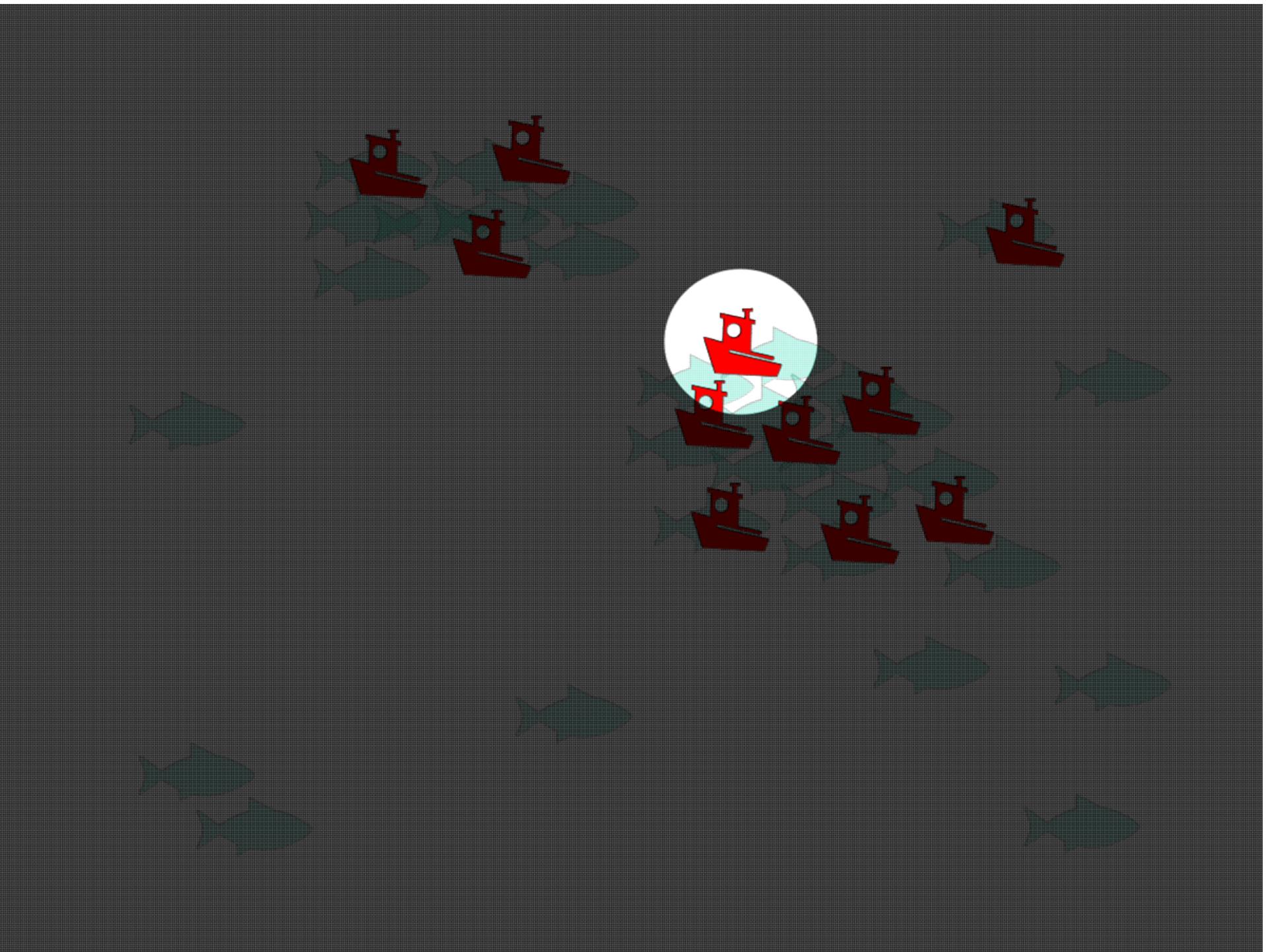
John Best

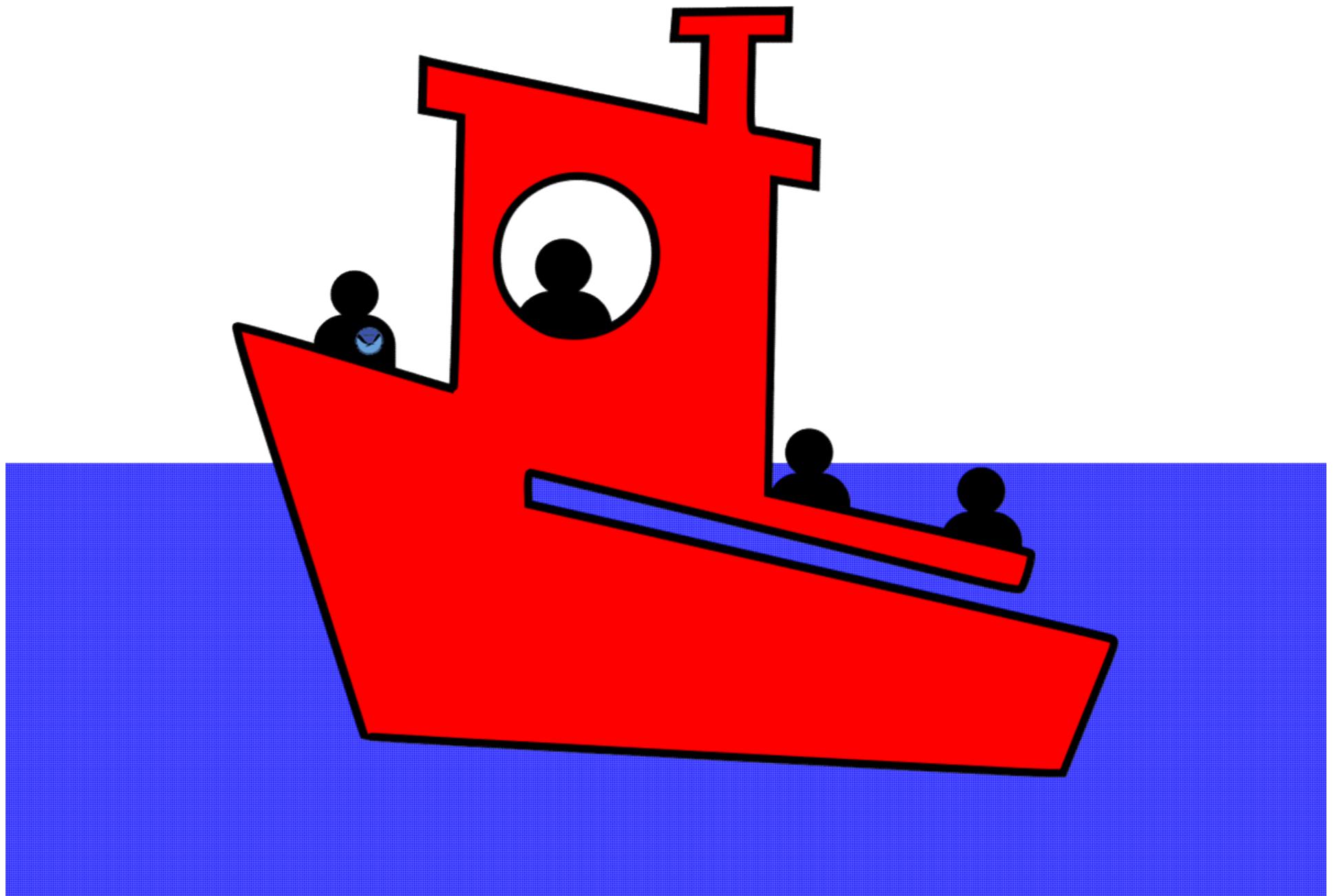
University of Washington

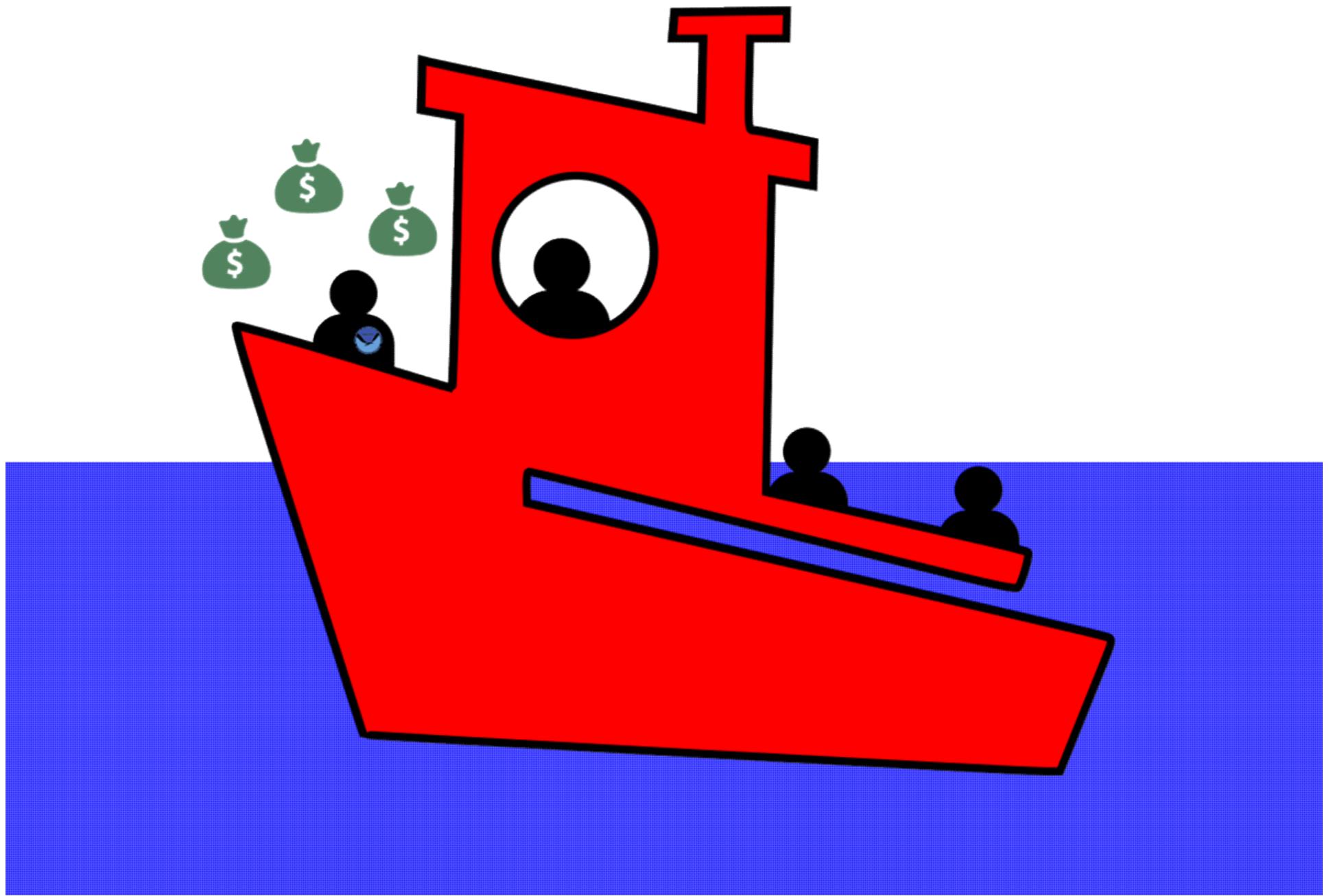








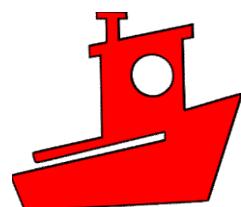




There's a lot more information in fishery data



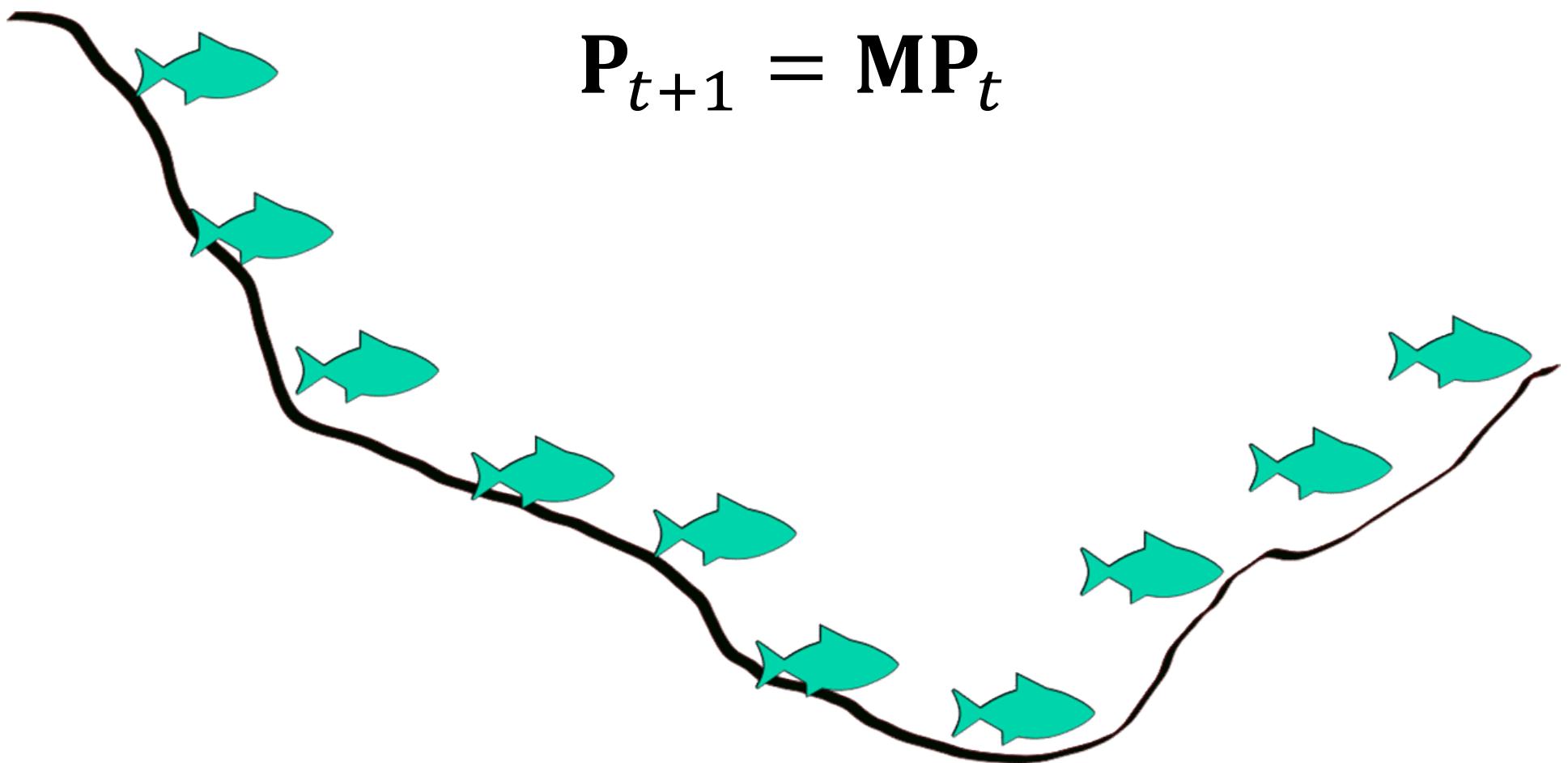
× 500



× 10,000

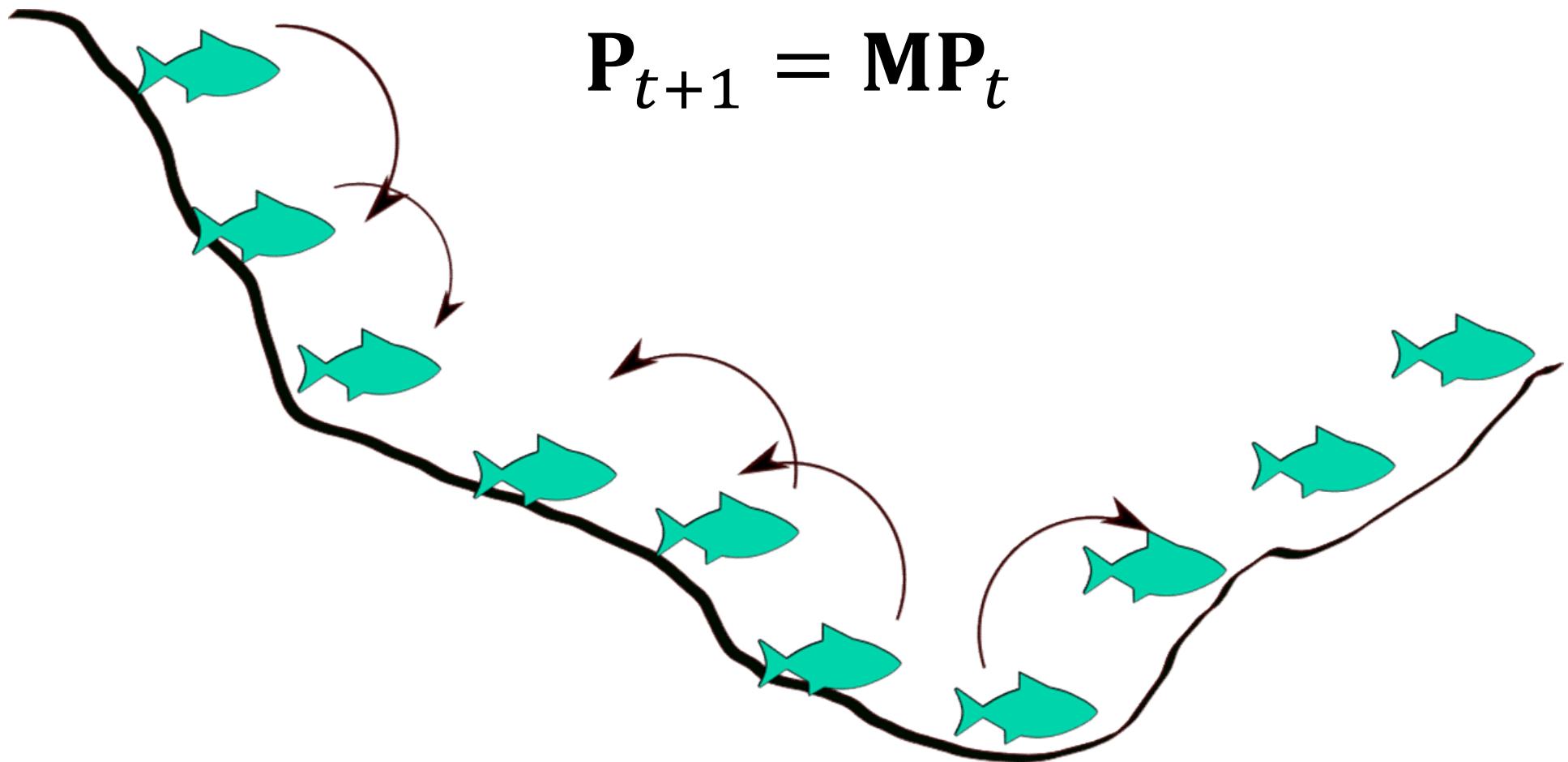
Spatial structure can be induced through movement

$$\mathbf{P}_{t+1} = \mathbf{M}\mathbf{P}_t$$



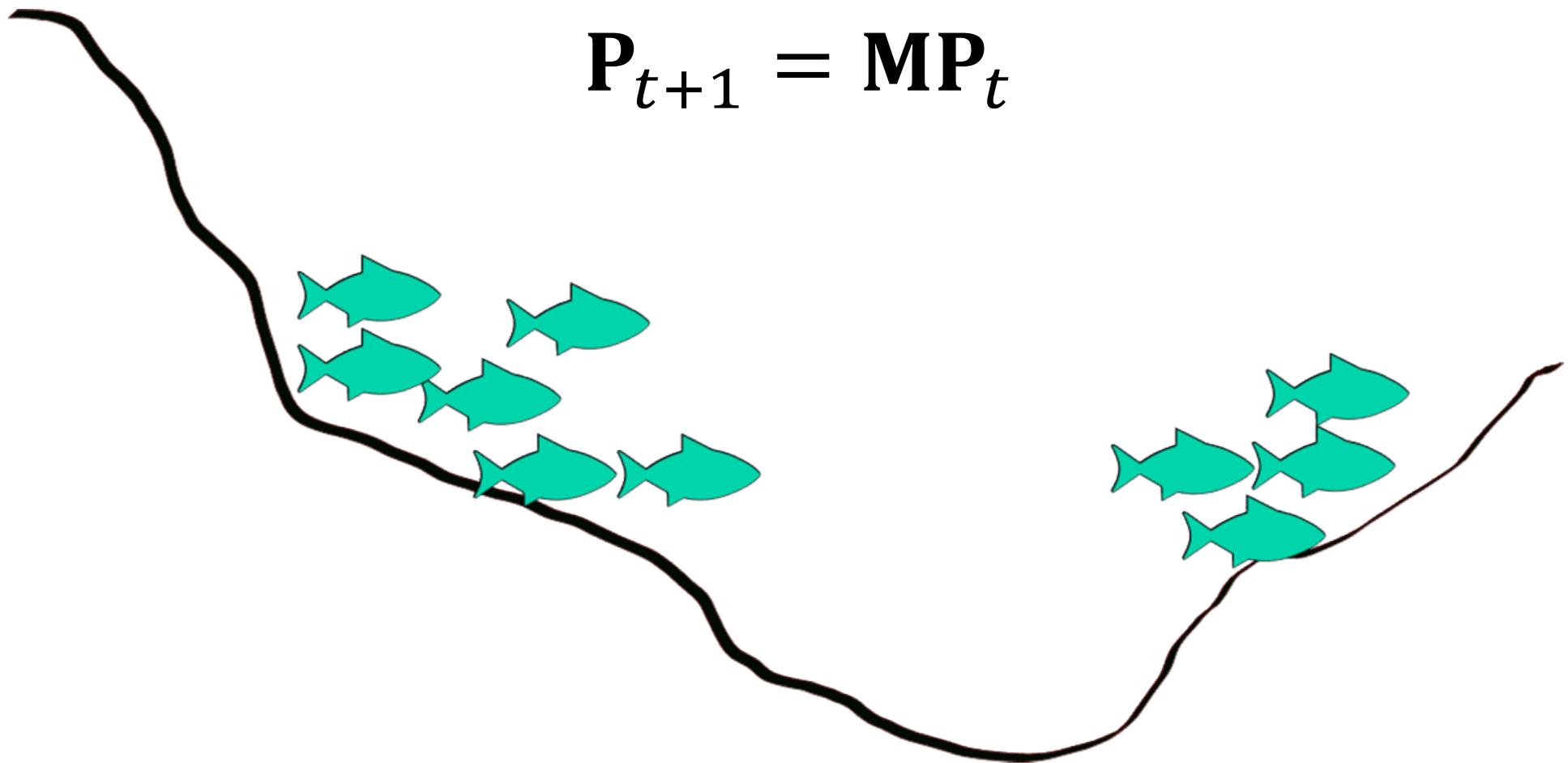
Spatial structure can be induced through movement

$$\mathbf{P}_{t+1} = \mathbf{M}\mathbf{P}_t$$

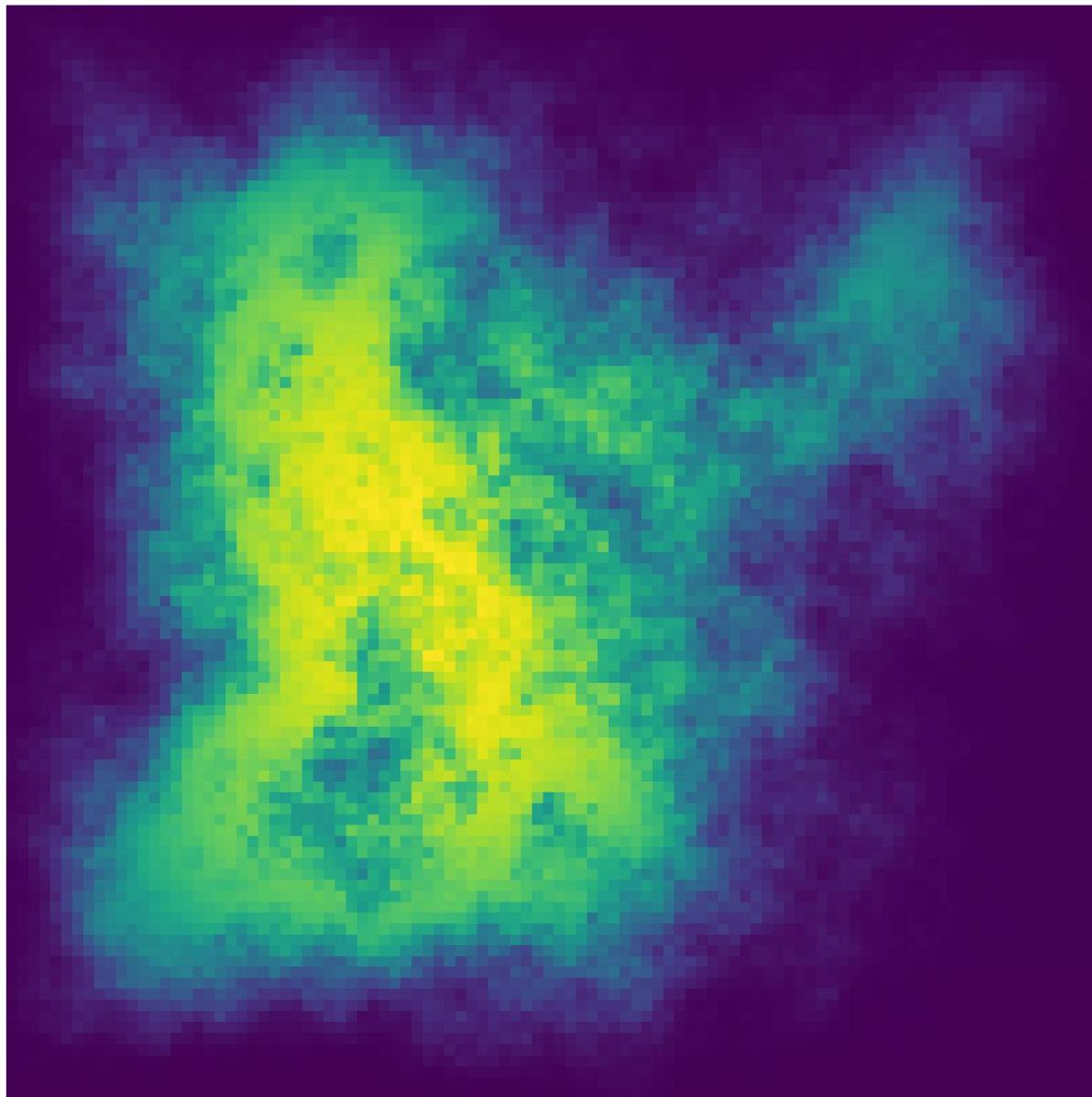


Spatial structure can be induced through movement

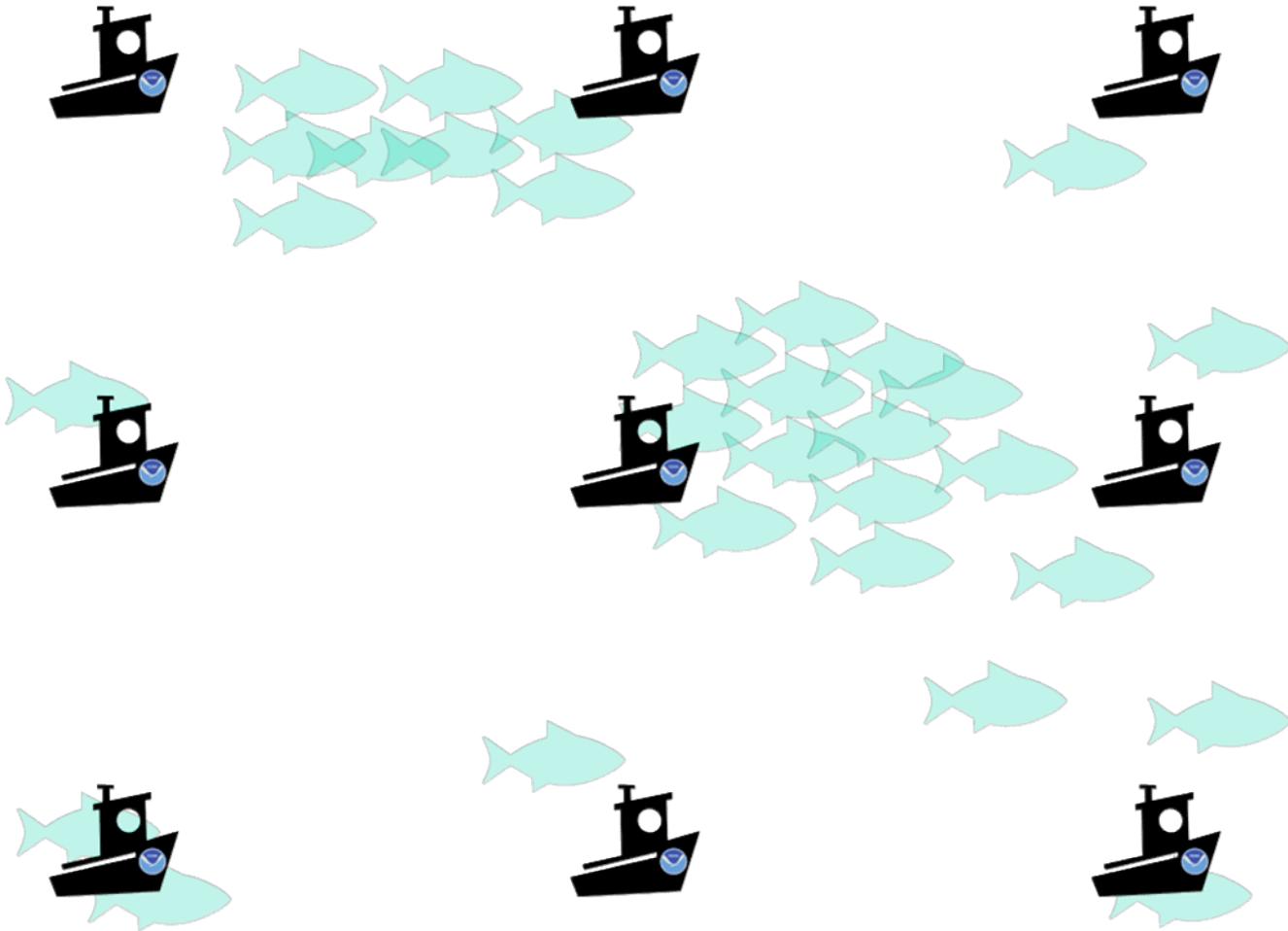
$$\mathbf{P}_{t+1} = \mathbf{M}\mathbf{P}_t$$



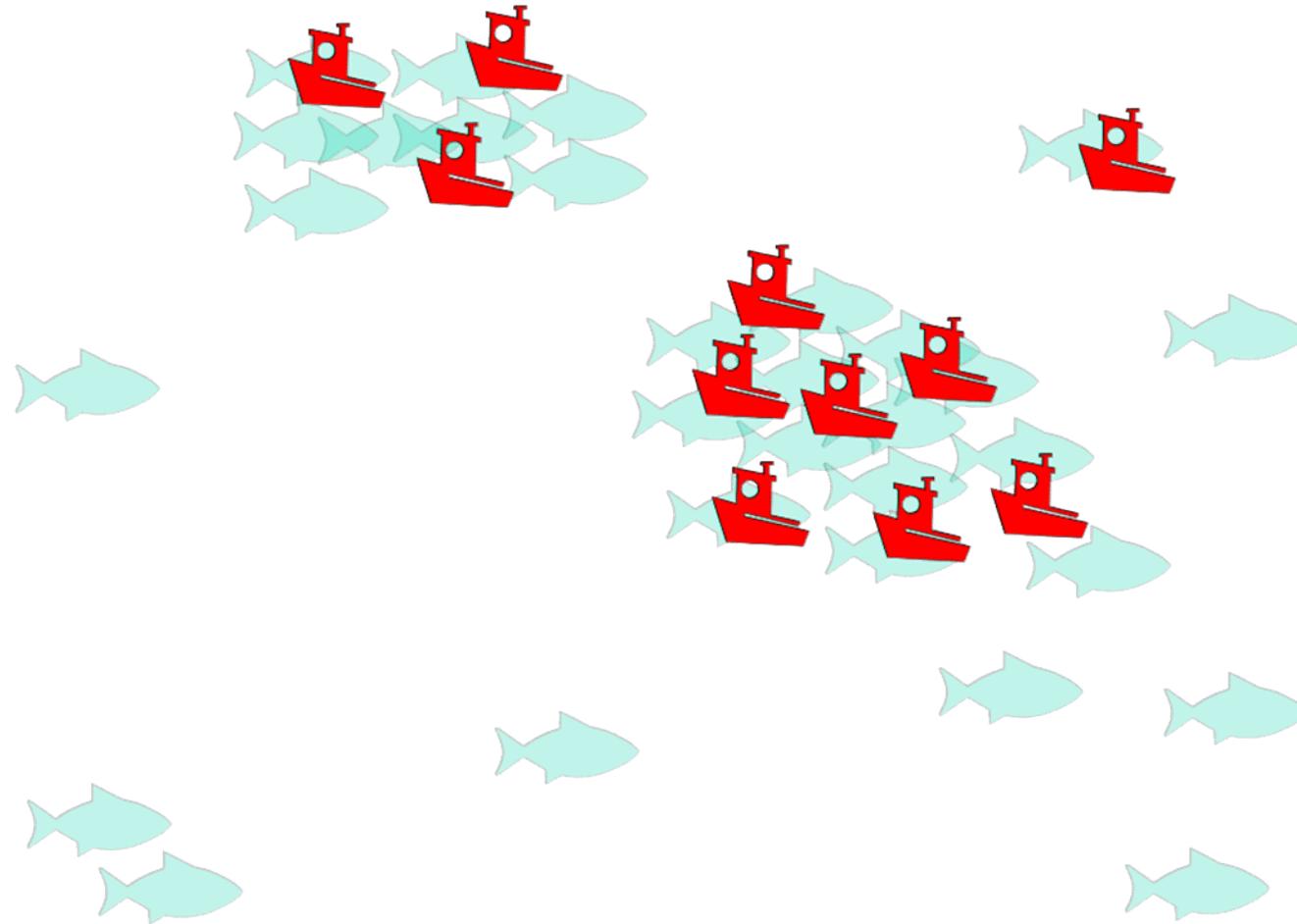
# Example abundance map



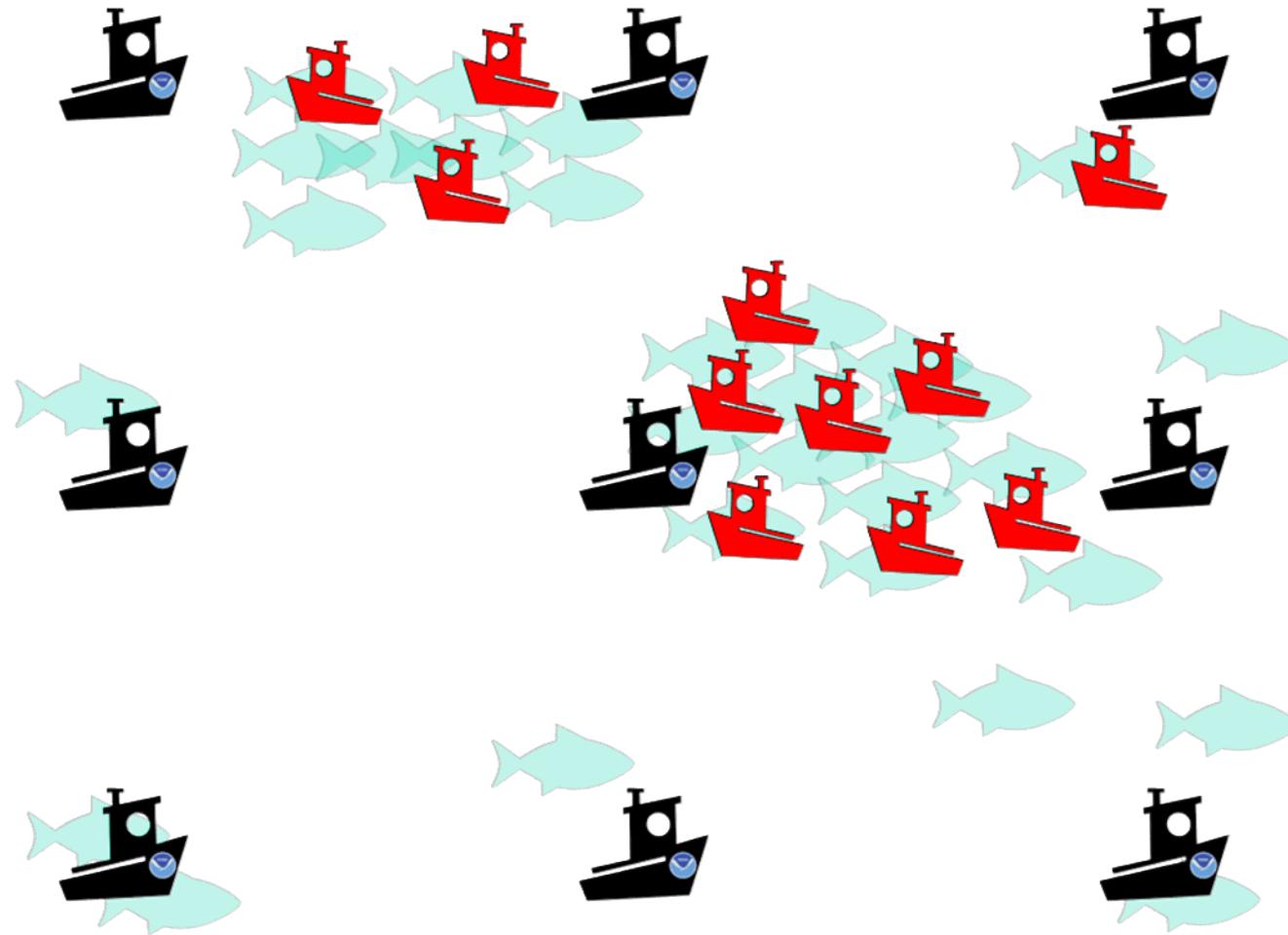
# Targeting varies by fleet



# Targeting varies by fleet



# Targeting varies by fleet



# Schaefer population dynamics

$$p_{s,t+1} = p_{s,t} + r p_{s,t} \left( 1 - \frac{\sum_s p_{s,t}}{K_t} \right)$$

$$K_t \sim \text{LogNormal} \left( \log(\bar{K}) - \frac{0.1^2}{2}, 0.1^2 \right)$$

VAST makes model fitting easy

$$r_1(s, t) = 1 - \exp([1 - a_i \exp(p_1(s, t))])$$

$$\Pr(C_{s,t} > 0) = r_1(s, t)$$

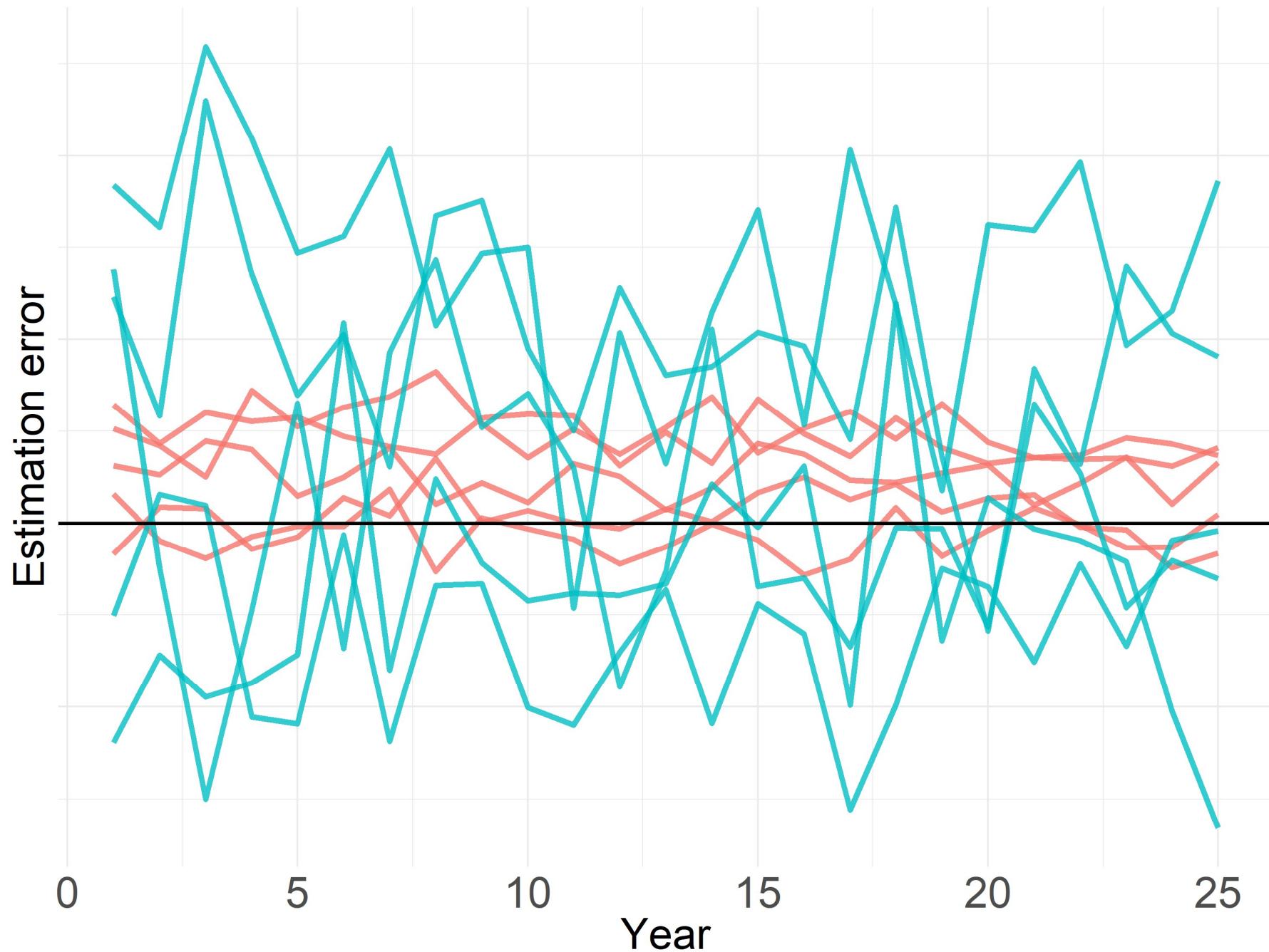
$$r_2(s, t) = \frac{a_i \exp(p_1(s, t))}{r_1(s, t)} \exp(p_2(s, t))$$

$$C_{s,t} \mid C_{s,t} > 0 \sim \text{LogNormal}(\log(r_2(s, t))), \sigma^2)$$

VAST makes model fitting easy

$$p_1(s, t) = \beta_1(t) + \omega_1(s) + \varepsilon_1(s, t)$$

$$p_2(s, t) = \beta_2(t) + \omega_2(s) + \varepsilon_2(s, t)$$



The bias is there for a reason

$$\mathbf{Y} = \beta_0 \mathbf{1} + \boldsymbol{\omega}$$

$$\boldsymbol{\omega} \sim MVN(0, \boldsymbol{\Sigma})$$

$$(\boldsymbol{\Sigma})_{ij} = k(s_i, s_j)$$

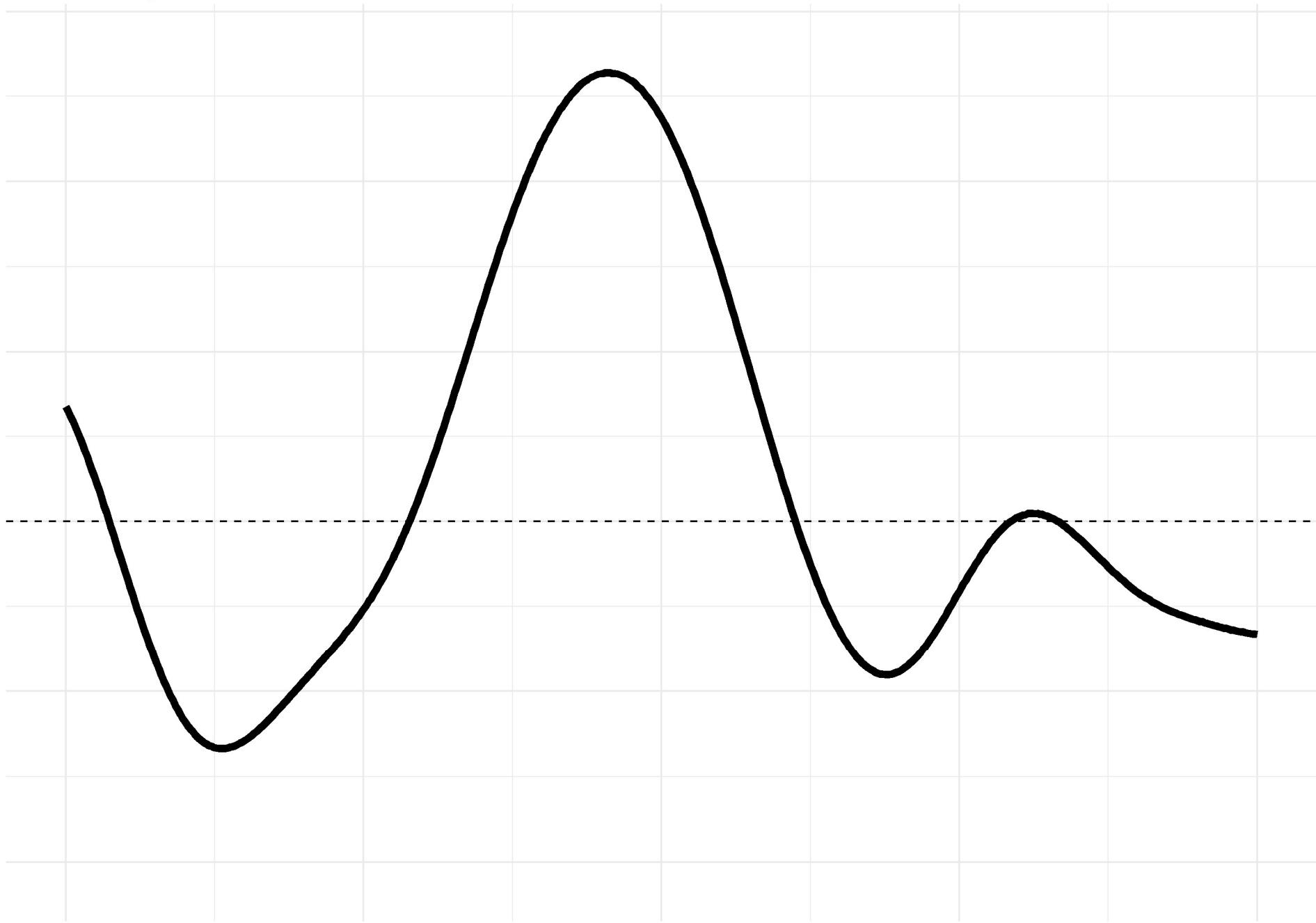
The bias is there for a reason

$$\mathbf{Y} = \beta_0 \mathbf{1} + \boldsymbol{\omega}$$

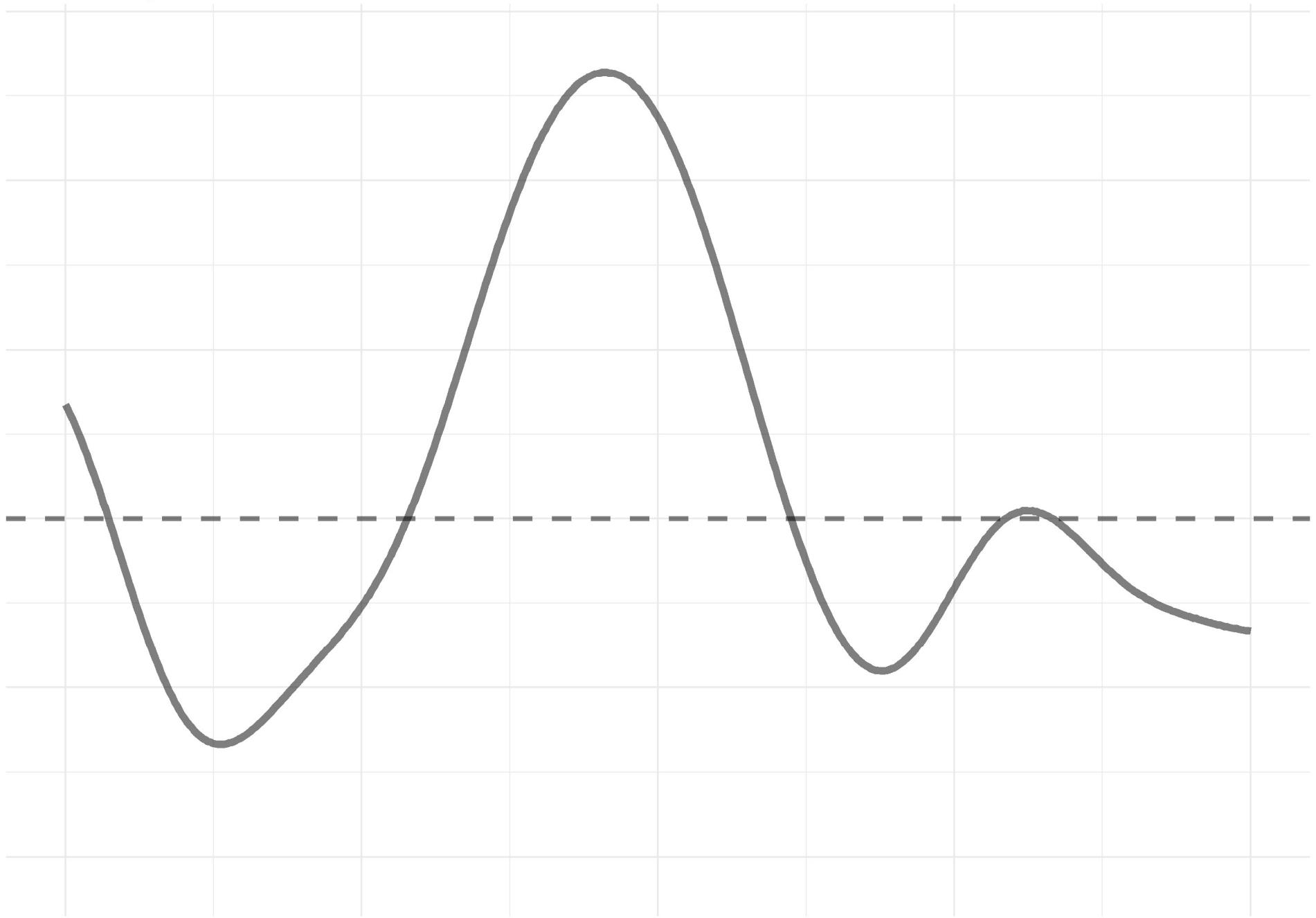
$$\boldsymbol{\omega} \sim MVN(0, \boldsymbol{\Sigma})$$

$$(\boldsymbol{\Sigma})_{ij} = k(s_i, s_j)$$

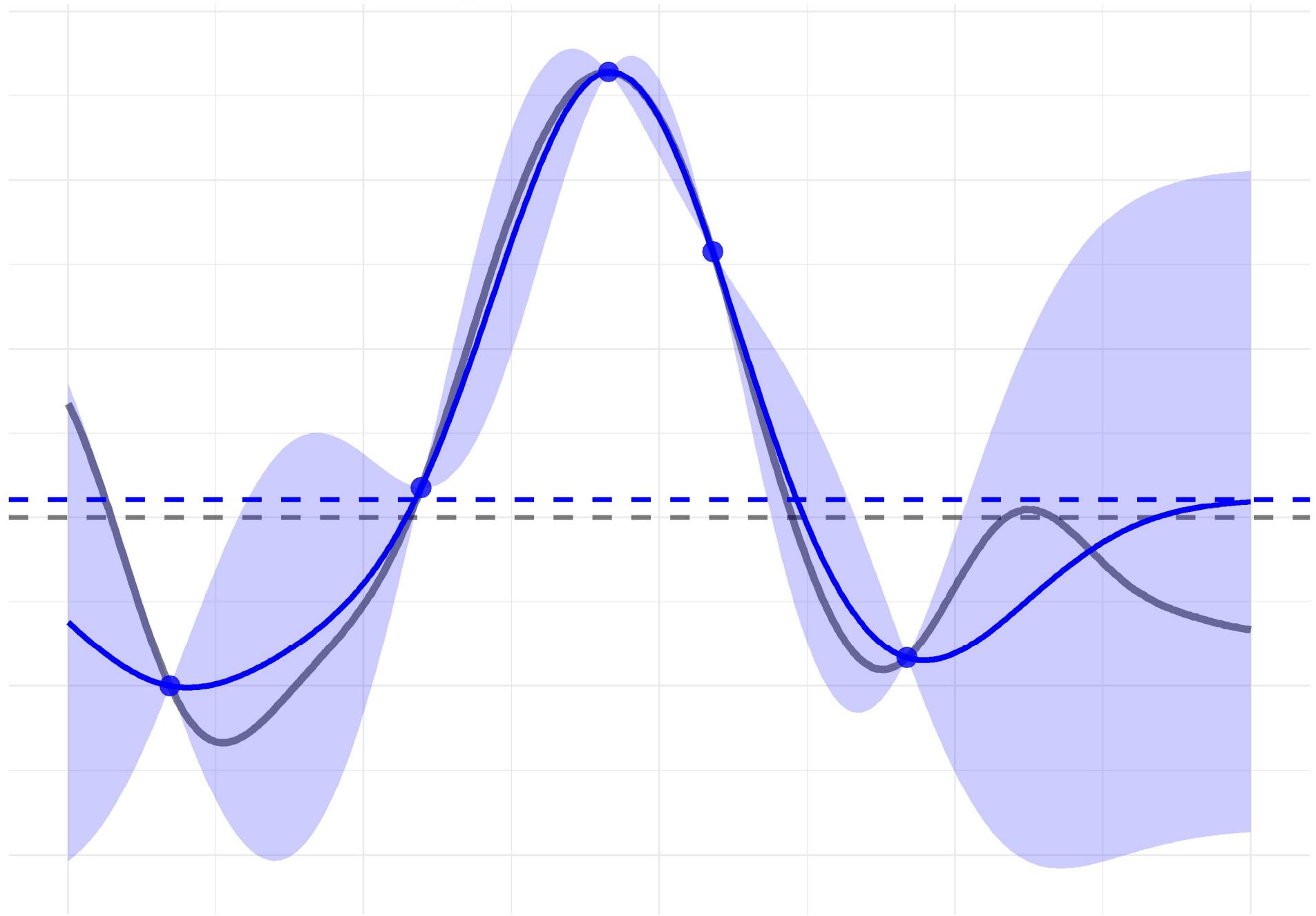
# True process



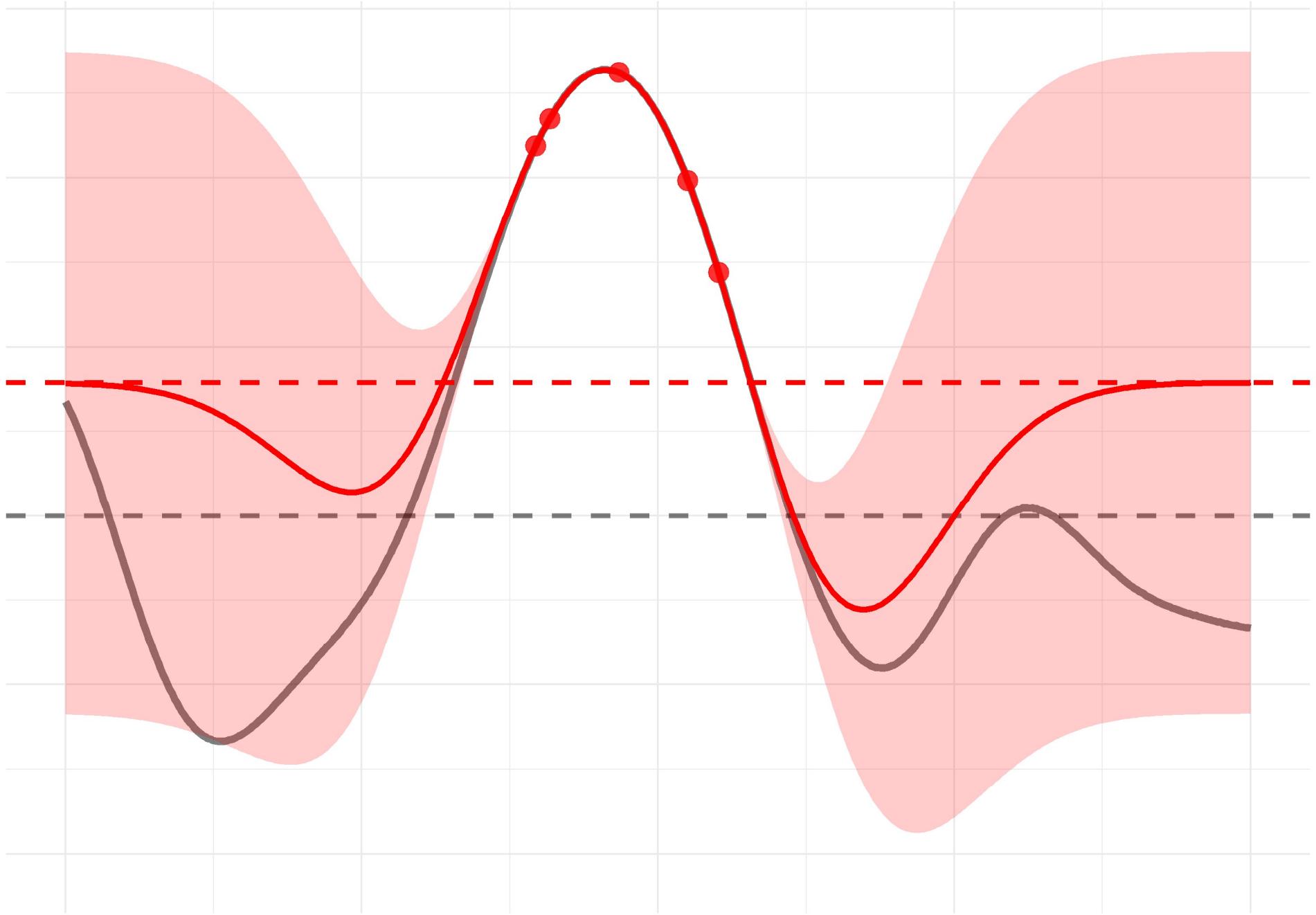
# True process



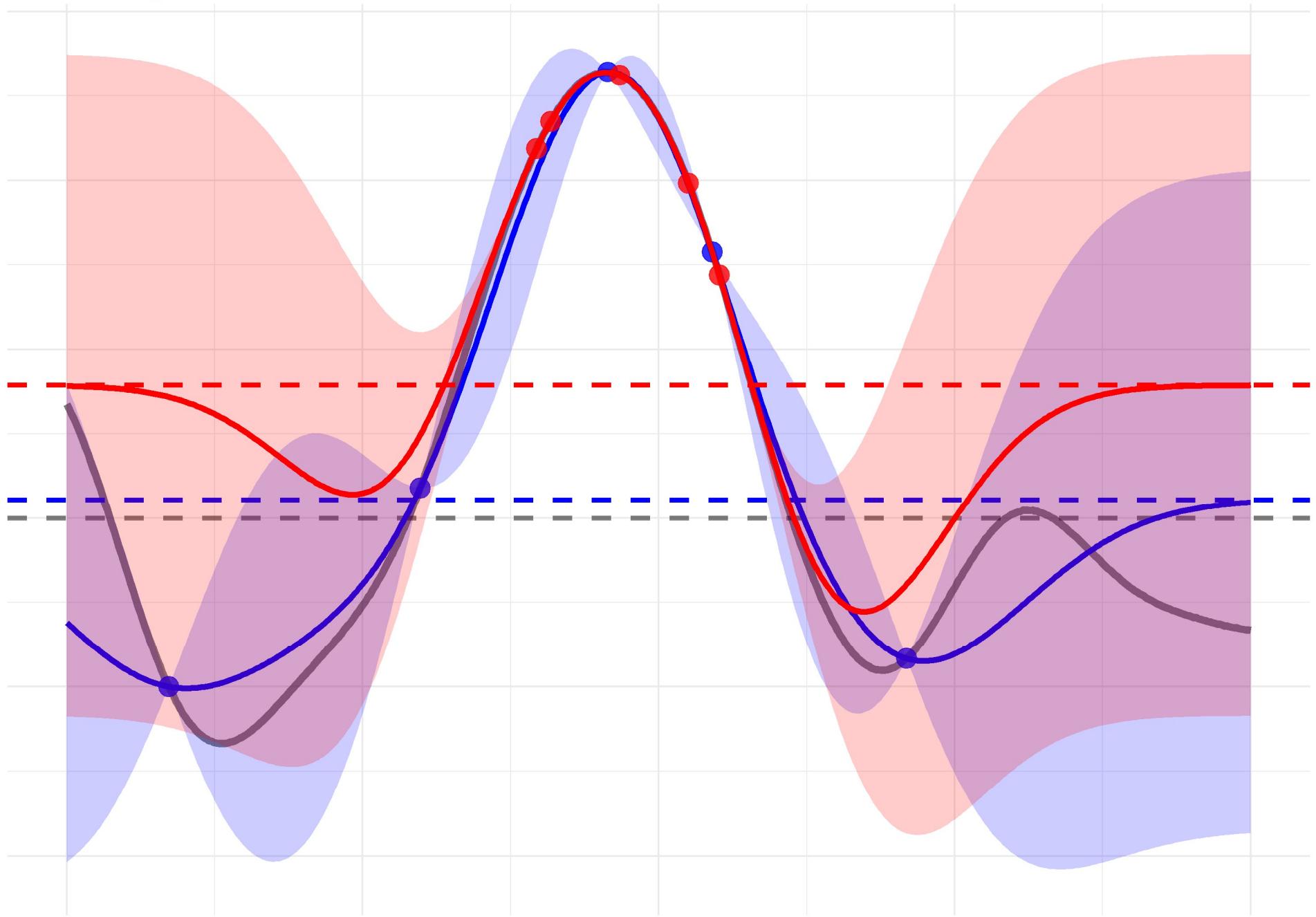
# Random sampling



# Preferential sampling



# All together now



There's a lot left to do

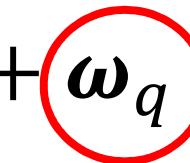
$$\log(\text{CPUE}_s) = \mu_s + \omega_d + \epsilon_s$$

$$\log(\text{CPUE}_f) = \mu_f + \omega_d + \omega_q + \epsilon_f$$

There's a lot left to do

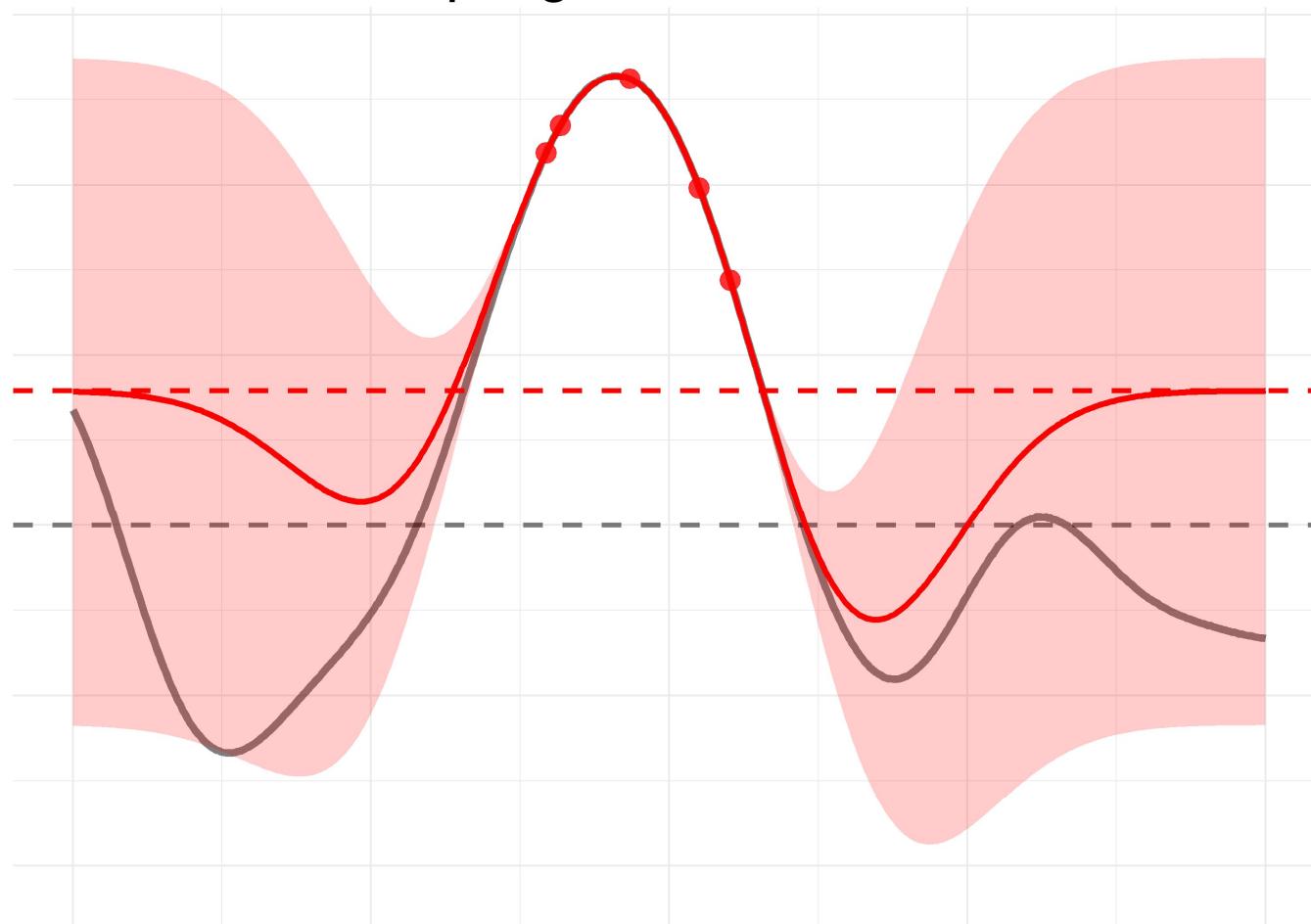
$$\log(\text{CPUE}_s) = \mu_s + \omega_d + \epsilon_s$$

$$\log(\text{CPUE}_f) = \mu_f + \omega_d + \omega_q + \epsilon_f$$



# There's a lot left to do

## Preferential sampling



# Acknowledgements

- Jim Thorson
- Andre Punt
- Rick Methot

$$QERM = \int_{i=1}^{\sum} \left( \text{Crab} + \frac{\text{Shark}}{\text{Fish}} \right) d\text{Fish}$$

*Quantitative Ecology & Resource Management  
University of Washington*

